Chapter Two: Description of Lands Included in the Finding

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A. Property Description

The Cook Inlet Areawide Sale area is divided into 815 tracts ranging from 640 to 5,760 acres, and is. within the Matanuska-Susitna Borough, Municipality of Anchorage, and the Kenai Peninsula Borough. The boroughs and municipality have the powers of taxation, land management and zoning and are responsible for providing borough communities with public works, utilities, education, health, and other public services. Over half of the population of the state resides in the area, and the region is the industrial and business center for Alaska. Residents use the area for recreation and for subsistence, personal use and sport hunting and gathering. See Figure 1.1, Map of the Cook Inlet Areawide Oil & Gas Lease Sale Area.

The surface estate of the uplands in the sale area is a complex mosaic of ownership categories. The predominant landowners are the federal and state governments. Other institutional land owners include the Matanuska-Susitna Borough, Municipality of Anchorage, Kenai Peninsula Borough, Cook Inlet Region Incorporated, village corporations, Mental Health Trust, and the University of Alaska. Private land holdings include subdivisions, homesites, Native allotments, homesteads, and mining claims (ADF&G, 1985b:875). There are more than 40,000 private land parcels in the tri-borough Cook Inlet Areawide region. Ninety-seven percent of the land offered in this sale has been offered before in previous lease sales.

The lands offered for lease in this Cook Inlet Areawide sale contain lands in which the state owns both the surface and subsurface estate, and lands where the state owns only the subsurface, while the surface might be either privately owned or held by a borough or municipality. A sub-surface land status atlas has been developed for this final best finding. For more information on the atlas or on how to determine if the state owns the subsurface, contact DO&G.

B. Subsurface Property and the Public Interest

In the late 1950's, Congress was debating the Alaska Statehood Act. A major concern was Alaska's ability to support itself since it did not have any industry. Statehood proponents saw federal land grants including the underlying natural resources as a way to secure the new state's financial well being.

The Statehood Act allowed Alaska to select 104 million acres of federal land as its economic base. The land grants included the right to all minerals underlying these selections. The Act specifically required the state to retain these mineral interests when conveying interests in the surface estate stating "mineral deposits in such lands shall be subject to lease by the State as the State legislature may direct" (P.L. 85-508, § 6(i)).[1] Additionally, the Act provided that if Alaska disposed of its mineral estate contrary to the Act, it would have to forfeit that mineral estate to the federal government.

In keeping with the Act, the Alaska Constitution mandates the state's policy: "to encourage … the development of its resources by making them available for maximum use consistent with the public interest"

[1] There are two types of interests or ownership in land, the surface estate and the subsurface or mineral estate. The interests may become separated when an original owner keeps only the surface estate and sells the subsurface, or when an owner sells only the surface and keeps the subsurface to sell or use later. Therefore, the surface and subsurface interests may be separate, and a property or homebuyer could buy land but acquire only the surface estate.

and the "legislature shall provide for the utilization, development and conservation of all natural resources belonging to the state, … for the maximum benefit of its people." Alaska Constitution, art. VIII, §§ 1, 2.

To comply with this mandate, the legislature enacted Title 38 of the Alaska Statutes and directed ADNR to implement the statutes. The legislature explicitly found that the people of Alaska have an interest in the development of the states oil and gas resources to maximize the economic and physical recovery of the resources. AS 38.05.180(a). The legislature found that it is in the best interests of the state to encourage an assessment of its oil and gas resources and to allow the maximum flexibility in the methods of issuing leases.

Congress, the drafters of the Alaska Constitution, and the Legislature intended that the subsurface estate belong to and financially benefit all Alaskans. That's why when state surface land is conveyed to an individual citizen, state law requires that the deed reserve oil and gas rights for the state. AS 38.05.125. To remove these state owned rights from an oil and gas lease sale because it is under a private surface owner's property would contradict the intent of state and federal law, and lessen the value of a state resource. All Alaskans could lose financially to benefit one landowner or a small group of landowners.

C. Geography of the Cook Inlet and Susitna Basins

1. Climate

In the Cook Inlet area, both north and south of the Forelands, the climate is transitional, having properties of both a maritime and a continental climate. As moisture-laden air masses from the Gulf of Alaska are lifted by the Kenai Mountains, condensation forms rain or snow. Most of the precipitation is deposited on the windward side and tops of the mountains. The southern coast receives about 50 inches of precipitation a year. In some areas of the Kenai Mountains, annual precipitation exceeds 100 inches falling mostly as snow. The upper Cook Inlet area receives 15 to 30 inches of precipitation a year (KPB, 1990:1-1).

Generally, an inland high-pressure cell characterizes winter with frequent storm progressions from the west along the Aleutian chain. During summer, low pressure develops over the inland area, with reduced storm passage. Summer and fall are characterized by a transition between these generalized patterns. (MMS, 1995:III.A.3)

The Chugach and Kenai Mountains experience heavy precipitation, cool summers and mild winters. Without the moderating effects of the Gulf of Alaska, air mass temperatures of the upper Cook Inlet area are more extreme. Occasionally during the winter months, this area will experience short periods of extreme cold and/or high winds when strong pressure gradients force cold air southward from interior Alaska (KPB, 1990:1-1). In winter and summer, moderately strong high-pressure cells develop over the coastal plains of Kenai and Anchorage and the Susitna Valley.

Prevailing winds and storm tracks are from the southeast. The surrounding mountains influence wind patterns. On the western side of Cook Inlet are the Alaska and Aleutian (Alaska Peninsula) Ranges; on the eastern side are the Talkeetna, Chugach, and Kenai Mountains and the lesser ranges of Kodiak and Afognak Island on the south (MMS, 1995:III.A.4). The strongest surface winds occur in the coastal area. Offshore winds average between 12 and 18 knots; the winds are slightly less onshore because of surface friction. Extremes of 50 to 75 knots are common in the winter, and can exceed 100 knots when channeled (AEIDC, 1974:12).

Channeling occurs when surface features constrict winds. For example, water may flow in a wide ocean channel at a speed of five knots. If the channel narrows, the speed of the current increases in order to carry an equal volume of water in an equal amount of time. Wind reacts the same way. Valleys or mountain passes form narrow channels. Under conditions common in the coastal mountains of Southcentral Alaska, wind speed may double or triple in narrow mountain channels. Ships traveling in the Gulf of Alaska have reported narrow bands of extremely strong winds flowing out of the valleys perpendicular to the Chugach Mountains. The strong winds found in the Turnagain Arm and Matanuska Valley are also examples of channeled winds (AEIDC, 1974:10).

Most scientists agree the earth has warmed about one degree Fahrenheit since 1850. Temperatures in Alaska and other high latitudes have experienced a one degree Fahrenheit increase each decade in the last 30 years. In the last five years, Southcentral Alaska summers have been warmer and dryer than average (ADN, 1997). This worldwide warming trend has helped to bring ecological changes to the Cook Inlet area.

"Three scales of climate warming can be seen in Kenai Peninsula tree-ring chronologies and meteorological records: a general warming since the end of the Little Ice Age (1850), a stronger post-1940's warming (mean annual temperature increase of 3 degrees F/50 years for Kenai, and 4 degrees F/50 years for Homer), and an especially strong post-1987 increase in summer temperatures in Kachemak Bay." (Berg, 1997)

Glacier retreat, rising timberlines, the desiccation of small ponds, and the black spruce invasion of wetland perimeters are all visible signs of the current warming trend. Wildlife biologists indicate that warmer temperatures may exacerbate spruce bark beetle outbreaks, and the cumulative effect of infestation, wildfires, and salvage logging pose a threat to brown bear habitat on the Kenai Peninsula (Berg, 1997). Precipitation is also a factor in spruce beetle infestations and fire events.

Research regarding the causes of the current warming trend is ongoing, and conflicting theories continue to be debated. One theory suggests that the increase in temperature is caused by an increase in greenhouse gas emissions (mostly carbon dioxide and methane) as a result of fossil fuel consumption and deforestation. Another theory suggests fluctuations in the amount of solar radiation reaching earth may have a bigger role in climate change than human pollution. This is based on observed correlations between sun spot activity and changes in the earth's climate. Yet another theory suggests that volcanic eruptions and other natural sources of greenhouse gases are the cause of the warming trend. Other scientists suggest it may be a combination of human and natural factors. A long-term view recognizes that ice ages are common events in the earth's history, and that the current era is simply an inter-glacial period (ADN, 1997). Recent evidence from tree rings, lakes, marine sediments, wetlands, and glaciers indicate that the current warming trend in the Arctic began in 1840 as a result of natural factors, and not because of 20th century industrial pollution. "Although warming, particularly after 1920, was likely caused by increases in atmospheric trace gasses, the initiation of the warming in the mid-19th century suggests that increased solar irradiance, decreased volcanic activity, and feedbacks internal to the climate system played roles." (Overpeck, et al., 1997).

2. Oceanography of Cook Inlet

This section describes the physical nature of the Cook Inlet waterway. Quality of Cook Inlet marine water is discussed in Chapter Five. Effects of oil and gas activities on biota of Cook Inlet are discussed in Chapter Six. Transportation of oil and gas, and oil spill prevention and response are discussed in Chapter Five.

a. Bathymetry

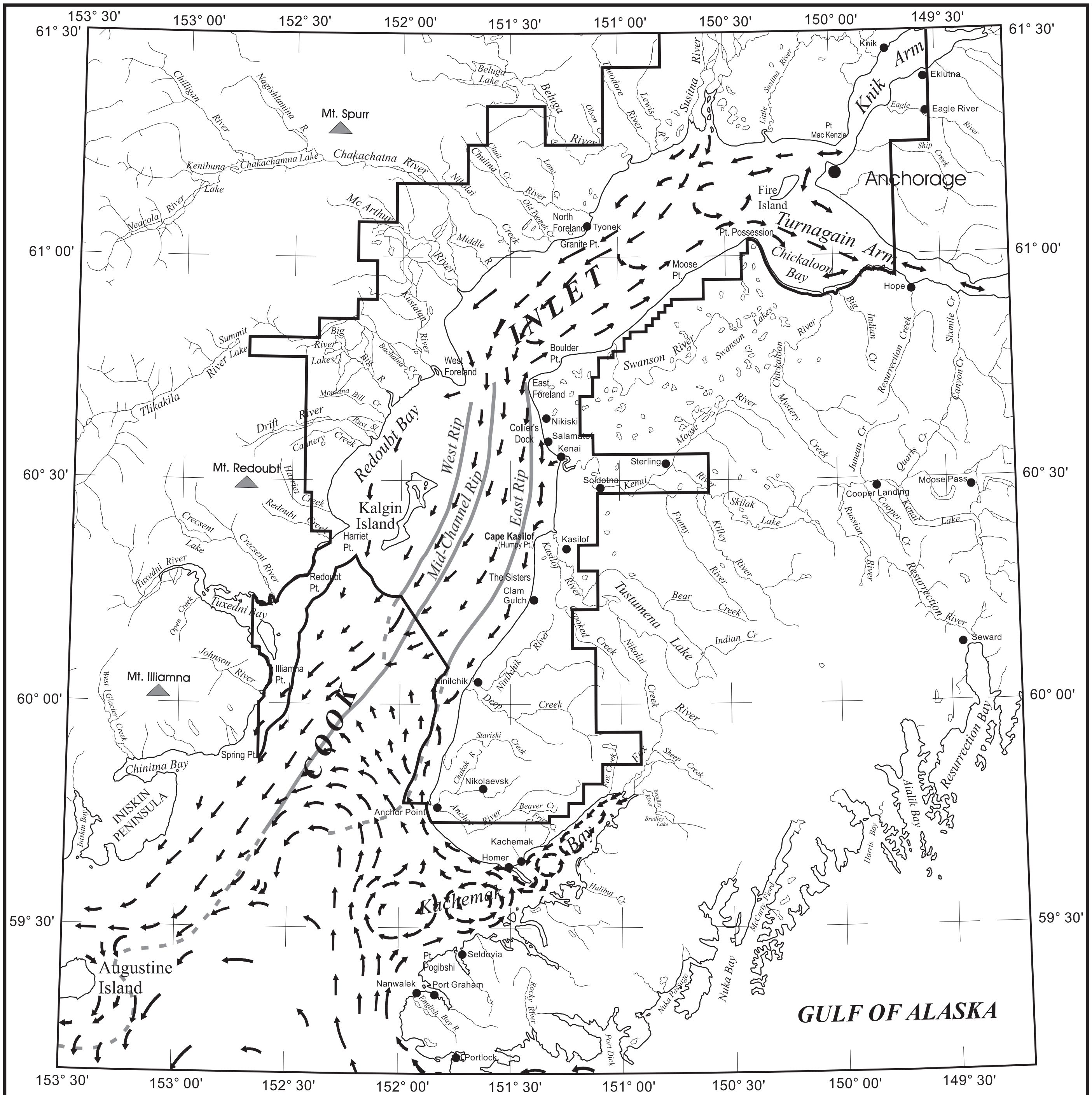
Cook Inlet is a semi-enclosed coastal body of water having a free connection to the open sea and within which the seawater collides with freshwater from land drainage. Cook Inlet channels, coves, flats, and marshes are nourished by the constant mixing of terrestrial source waters and marine waters of Shelikof Strait and the Gulf of Alaska (MMS, 1995:III.A.5).

The bottom of Cook Inlet is extremely rugged with deep pockets and shallow shoals. The depths in the upper inlet north of the Forelands are generally less than 120 feet, with the deepest portion located in Trading Bay, east of the mouth of the McArthur River. South of the Forelands, two channels extend southward on either side of Kalgin Island and join in an area west of Cape Ninilchik. South of the cape, this channel gradually deepens to approximately 480 feet and widens to extend across the mouth of Cook Inlet from Cape Douglas to Cape Elizabeth (KPB, 1990:1-4). The bottom of Cook Inlet consists predominately of cobbles, pebbles, and sand with minor proportions of silt and clay (MSB, 1983:2-10).

b. Tides and Currents

Tides in Cook Inlet are semidiurnal, with two unequal high tides and two unequal low tides per tidal day (24 hours, 50 minutes). The mean diurnal tidal range varies from 18.7 feet at Homer to 29.6 feet at Anchorage (MSB, 1983:2-9). This high tidal range distinguishes Cook Inlet's coastal ecosystem from others in the Pacific Northwest.

The mixing of incoming and outgoing tidewater, combined with freshwater inputs, are the main forces driving surface circulation (MMS, 1995: III.A.6) (See Figure 2.1). Strong tidal currents and inlet geometry produce considerable cross currents and turbulence within the water column. Tidal bores of up to 10 feet have occurred in Turnagain Arm (KPB, 1990:1-4). Bottom current speeds of 1.2 to 1.8 knots can be estimated from the formation of sand bottom waves in the mud flats (MSB, 1983:2-9). Current velocities are also influenced by local shore configuration, bottom contour and possibly wind effects in some shallow areas. Maximum surface current speeds average about three knots in most of the Inlet; however, currents may exceed 6.5 knots in the Forelands area. Current speeds of up to 12 knots have been reported in the vicinity of Kalgin Island and Drift River (KPB, 1990:1-4)



Surface Currents

Cook Inlet Areawide =

Surface Currents =

General Rip Zones =

SOURCE: NOAA, Cook Inlet and Kenai Peninsula, Environmentally Sensitive Areas Dec., 1994.

SCALE 1:1,425,600 ONE INCH EQUALS 22.5 MILES APPROX.

20 0 20 40 60 80 MILES

20 0 20 40 60 80 100 120 KILOMETERS

ALBERS EQUAL-AREA CONIC PROJECTION BASED ON THE CLARK 1866 ELLIPSOID

ADNR 3/98

FIGURE 2.1

c. Sediment and Salinity

Cook Inlet receives immense quantities of glacial sediment from the Knik, Matanuska, Susitna, Kenai, Beluga, McArthur, Drift, and other rivers. This sediment is redistributed by intense tidal currents. Most of this sediment is deposited on the extensive tidal flats or is carried offshore through Shelikof Strait and eventually deposited in the Aleutian trench beyond Kodiak (AEIDC, 1974:109). Powered by the Alaska Coastal Current, sediments of the Copper River drainage drift into lower Cook Inlet and Shelikof Strait where they eventually settle to the bottom. Recent survey results of the MMS indicate that about half of the bottom sediments in Shelikof Strait are from the Copper River (Prentki, 1997).

Longshore transport of sediment within Cook Inlet is generally up the Inlet, although Kamishak, Tuxedni and Kachemak Bays are areas where this trend is reversed. Homer Spit, in fact, is maintained by longshore sediment transport from the north (KPB, 1990:1-5). Rain and snow events and glacial dam flooding also deposit significant amounts of sediment into Cook Inlet.

Salinity increases rapidly and almost uniformly down the inlet, from Point Possession to East and West Foreland. Slightly higher salinities are found on the east side. This rapid increase can be attributed to heavily loaded glacial runoff from the Matanuska, Susitna and Knik Rivers and subsequent sediment settling in upper Cook Inlet. Local areas of depressed salinity occur off the mouth of large glacially fed streams, such as the Tuxedni, Kenai, and Kasilof Rivers (KPB, 1990:1-5).

d. Water Temperature and Ice Conditions.

The water temperature in upper Cook Inlet varies with season from 32° to 60° F. The lower Cook Inlet is affected by the intrusion of warmer waters from the Gulf of Alaska; and temperatures range from 48° to 50° F.

The ice in Cook Inlet comes from four different sources: sea ice, beach ice, stamukhi, and estuary and river ice. Sea ice forms in seawater and is the predominant type in Cook Inlet. Beach ice is composed of frozen mud exposed to the air by the ebbing tide. At flood tide, water in contact with the frozen mud also freezes. Stamukhi are comprised of beach ice which has broken free, been deposited higher on the mud flats and frozen to the underlying mud. Ice floes floating toward the beach are caught on top of the higher piece of ice and as the tide recedes, the overhanging pieces break off, leaving a stack of layered ice. Estuary ice forms in estuaries and river ice in rivers: both are comprised of freshwater. River ice is much harder than sea ice and is unaffected by tidal action until spring breakup (LaBelle, 1983).

The primary factor for ice formation in upper Cook Inlet is air temperature, and the major influences in lower Cook Inlet is the Alaska Coastal Current temperature and inflow rate (MMS, 1995: III.A.6). Cook Inlet ice often first forms in October and melts before ice of a more permanent nature forms in the latter half of November. All ice generally disappears in early April, but some occasionally persists into May (LaBelle, et al., 1983). Ice occasionally drifts as far south as Anchor Point. Ice concentrations have been observed in Kamishak Bay extending outward to Augustine Island. Chinitna, Tuxedni and other western Cook Inlet bays may also have occasional ice cover (KPB, 1990:1-5).

Tidal action and tidal currents leave inlet ice in a shattered condition. Ice flows that are moved by tides and winds can gouge shorelines, cause shoreline erosion and exert significant forces on offshore structures (MSB, 1983:2-35). For oil and gas exploration activities from a jack-up rig, the window of operation is generally mid-April to mid-November. However, production platforms are designed to withstand ice conditions year-round (Van Dyke, 1996). Transportation, oil spills, and geophysical hazards are discussed in Chapter Five.

3. Hydrography of groundwater, lakes and streams

This section describes the surface and groundwater resources of the sale area. Section "a" describes the major surface water inputs to Cook Inlet. Information on groundwater occurrence, yield and usage is presented in Section "b". Section "c" describes drinking water resources and natural quality of groundwater of the Cook Inlet basin. The potential for contamination of ground and surface waters of Cook Inlet by oil and gas activities is discussed in Chapter Five. Cumulative effects are discussed in Chapter Six.

a. Surface Watershed

Precipitation falling on land follows paths both beneath and above the surface. Water held in lakes, streams, marshes, and swamps is called surface water and may be fed by groundwater aquifers in addition to surface sources. Water in the liquid state that occupies openings in the soil is called subsurface water; most of which is held in deep storage as ground water (Strahler and Strahler, 1984).

For six to nine months of the year, much of the fresh surface water in the sale area is stored in a frozen and relatively immobile state. Summer months begin with a period of intense hydrologic activity resulting from spring thaw or "break up." During this brief period, precipitation accumulated over winter discharges into Cook Inlet river and lake systems, infiltrates into ground water aquifers, and eventually carries water and sediment to marine waters. This rapid spring thaw is a critically important event for fish, wildlife and the timing of all human activities on land and at sea.

Water is stored for long periods in glaciers, providing a source of river inflow other than precipitation and ground water discharge. Data from the 1970's indicates a strong relationship between stream flow and groundwater seepage. Sixty-one percent of the Anchor River and 68 percent of the Ninilchik River flow are obtained from groundwater (base-flow) (Nelson and Johnson, 1981). Most major rivers in the Cook Inlet basin follow geologic faults in the earth's upper crust. Other streams and creeks follow paths of least resistance and are principally erosional phenomena. Depending on streambed parent material, rivers and streams in Cook Inlet lowlands are braided or meandering when primary stream inputs are glacially fed and not clear (spring fed).

Virtually all river systems passing through the region eventually drain into Cook Inlet. The region can be divided into major watersheds: Kenai Peninsula, West-side rivers, Susitna, Matanuska and Knik, and Anchorage bowl. Data on river discharge are collected by USGS.

The following listing of rivers and streams is unavoidably incomplete because the task of cataloging and naming all streams in Cook Inlet (and Alaska) is incomplete. However, starting with principal surface streams on the west side of the Inlet and moving in a counter-clockwise direction, the principal rivers include the Beluga, Chuitna, Chakachatna, Middle, McArthur, Kustatan, Big, Seal, Drift, Crescent, Tuxedni, and Johnson. Smaller creeks are Threemile, Lone, Tyonek, Old Tyonek, Nikolai, Stedatna, Chuitkilnachna, Bachatna, Montana Bill, Cannery, Katchin, Harriet, Redoubt, Little Polly, Polly, Open, Difficult, Hungryman, and Bear. Important sloughs are Johnson, Cottonwood, Seal, Rust, and Little Jack. There are also numerous smaller or unnamed streams and tributaries that drain the uplands and lowlands of west Cook Inlet. Important lakes feeding into the Inlet are Beluga, Lower Beluga, Chakachamna, Blockade, Bunitlana, Big River, and Crescent lakes. Countless streams, tributaries, and lakes on the west side of Cook Inlet are unnamed or still undiscovered.

Swamp Creek and Packers Creek Lake are located on Kalgin Island. Kenai Peninsula streams also flow into the Inlet. Starting at Chikaloon Bay in the north, principal rivers on the east side of Cook Inlet are the Chickaloon, Swanson, Moose, Funny, Killey, Kenai, Kasilof, Ninilchik, Fox, Chakok, and Anchor. Smaller creeks are the Little Indian, Big Indian, Pincher, Bedlam, Miller, Seven Egg, Otter, Soldotna, Beaver (near

Nikiski), Bishop, Slikok, Coal, Crooked, Deep, Clam, Happy, Stariski, Travers, Twitter, Bridge, Diamond, Fritz, Beaver (near Homer), McNeil, Eastland, Falls, Swift, Moose, Fox, and Nikolai. Important lakes in or adjacent to the sale area are Skilak, Tustemena, Swanson, Browns, Mackeys Lakes, Cohoe, Caribou, and many more smaller lakes. There are hundreds of unnamed lakes in the Kenai Moose Range, Kenai National Wildlife Refuge and countless other lakes and tributaries in the foothills of the Kenai mountains.

The Placer and Twentymile Rivers dominate freshwater discharge into Turnagain Arm. Other inputs include Resurrection, Palmer, Six-mile, Seattle, Ingram, Portage, Glacier, Penguin, Bird, Indian, Rainbow, and McHugh Creeks. Principal freshwater inputs into the Anchorage bowl area include Potter, Rabbit, Campbell, Chester, Fish, and Ship Creeks.

The Matanuska and Knik Rivers dominate discharge into Knik Arm. Other freshwater inputs to Knik Arm from the south include Eagle River, Peters Creek, Thunderbird Creek, Eklutna River, Goat Creek and Hunter Creek. Major freshwater inputs into the Matanuska River and Knik Arm from the north near Palmer include Friday, Jim, Bodenburg, Wolverine, Granite, Carpenter, Young, and Moose Creeks. Numerous streams flow directly into Knik Arm on its north shore including Rabbit, Wasilla, Crocker, O'Brien, Threemile, Goose and Mule Creeks. In this extensive watershed, most small tributaries are unnamed.

The Susitna River provides the largest freshwater input component to upper Cook Inlet. Alexander and Fish Creeks also flow into the Susitna River. In addition to Matanuska, Susitna, Knik, and Turnagain Arm inputs, the Little Susitna River and Maguire Creek flow directly into upper Cook Inlet west of Point MacKenzie. Mount Susitna and Beluga Mountain form the divide between Susitna and Beluga River drainages.

Major lakes in the region include Caribou, Tustumena, Skilak, Kenai, Eklutna, Big, Redshirt, Horseshoe, and Chakachamna Lakes. As is characteristic of a glacial outwash plain, clusters of lakes also dot lowland portions, especially on the northern Kenai Peninsula and Nancy - Big Lakes region.

b. Groundwater Resources

i. Generalized Processes

Groundwater flows through openings in rock and unconsolidated sediments, and eventually reaches streams, lakes or the ocean. As precipitation flows through soils and vegetation, it picks up soluble minerals and absorbs organic materials, constantly changing its chemical composition. Water that has been in contact with sediments deposited in a marine environment may contain high levels of sodium and chlorine. Waters associated with oil and gas deposits often contain hydrogen sulfide, marked by an unpleasant odor (Glass, 1995:25). Undesirable concentrations of iron are present in shallow wells in most areas of the state and moderately toxic levels of arsenic occur naturally in glacial clay at Anchorage and Kenai (Zenone and Anderson, 1978:17)(Glass, 1995).

An aquifer is the rock mass or sediment layer that readily transmits and holds groundwater. A confined aquifer is one bounded above and below by impermeable beds or by layers with a much lower ability to transmit or carry fluids than that of the aquifer itself. An unconfined aquifer contains groundwater not confined under pressure between two relatively impermeable layers (Glass, 1995:p.49).

All water-producing formations in Alaska have been grouped into two principal aquifers, unconsolidated alluvium and glacial outwash deposits, and bedrock. Most groundwater development in Alaska has been in unconsolidated aquifers, and about one percent of the state's total groundwater withdrawal is from bedrock. "All high-capacity industrial and municipal wells in the Cook Inlet basin are completed in unconsolidated materials." (Nelson and Johnson, 1981:4).

Water tables generally conform to surface topography close to surface water levels in valleys and are higher beneath watershed divides and hilltops. In periods of high precipitation as in spring, the water table rises and in periods of drought, it can fall. Depth to the water table is also affected by ground water seepage and inflow of nearby streams and marshes or bogs (Strahler and Strahler, 1984).

An aquifer's water supply is recharged by precipitation, infiltration of surface water from lakes or streams, or by some other subsurface water source. Likewise, aquifers may discharge water at surface openings, into lakes and streams, or into other aquifers. High pumpage or variability in annual precipitation may result in local reductions in water tables in wells, however, "[u]nder natural conditions, a long-term equilibrium exists between ground water entering and leaving an aquifer system. Groundwater discharge estimated from stream flow data should thus approach the long-term average ground water recharge in the area contributing to stream flow." (Zenone and Anderson, 1978:15)

The geologic age or glacial period during which its host material was formed or deposited, such as Quaternary or Tertiary, may broadly describe an aquifer. Generally, two or three predominant aquifers exist in the Kenai Peninsula, but over geographic distances, the presence of these layers and their hydraulic connectivity vary widely. Whether one source of ground water, in the form of a well or a spring at the surface, is connected to another source depends on factors such as local aquifer distribution; soil type; strata thickness, porosity, depth, gradient, and permeability; proximity of surface and other groundwater sources; and other hydrologic parameters.

Jurassic and Cretaceous-age bedrock in the sale area have little or no intergranular porosity, so that groundwater is confined to and transmitted through fractures. The sedimentary bedrock of the Kenai Group is relatively porous and is found beneath Quaternary sediments on the southern half of the Kenai Peninsula. In the northern peninsula, near Nikiski, depth to the Kenai Group bedrock is greater (Glass, 1995:20). "Poorly consolidated sediments of the Kenai Group are the principal source of groundwater in the study area. However, sparse data preclude defining the distribution of aquifers in the Kenai Group."(Nelson and Johnson, 1981:30). "Water in the Kenai Group may be unconfined or may be confined by silty claystones within the Kenai Group or by glacier till." (Glass, 1995:21). This in part explains the marshy nature of much of the Kenai Peninsula Lowland.

Aquifer assessment requires information collected from wells including well location, depth, yield, topsoil thickness, water-bearing zone thickness, well finish, reported yield, well status, and water quality data. Most data consist of localized reconnaissance reports by federal and state agencies, educational institutions, private contractors, and industry. Often these studies are collaborative efforts by parties with an interest in local groundwater quality and abundance. Aquifer assessment is based on individual well data, therefore, data from these studies are highly site-specific and it may be difficult to apply area-wide generalizations about the spatial distribution of aquifers.

A review of available literature on surficial geology and hydrography suggests that aquifer depth, thickness, composition and distribution is discontinuous throughout the area of analysis (and Alaska). Site-specific data and some field-testing are required for an analysis of local conditions. "Stratigraphic complexities normally associated with glacially derived deposits ... give rise to various degrees of hydraulic connection between aquifers." Subsequently, "an aquifer's yield is greatly dependent on the characteristics of adjoining confining beds (less permeable deposits) and aquifers." (Freethy and Scully, 1980) It is not uncommon for neighboring domestic wells to be very different. "The depths, yields, water levels, and water quality of closely spaced wells are commonly dissimilar." (Glass, 1995:21)

When there is a lack of data on groundwater hydrology and aquifer lithology, "probably the best quantitative estimate of regional groundwater budgets in Alaska can be made from analysis of stream flow records that are available throughout the State." (Zenone and Anderson, 1978:15). This is usually done when a specific project is proposed.

ii. Local Well Water

Anchorage Bowl Groundwater

Principal producing aquifers in the Anchorage lowlands are confined. The permeability of the confining layer gradually increases towards the mountains. In a transition zone below the foothills, surface water percolates into the ground and recharges the sand and gravel aquifers that extend westward into the confined zone. As with most lowland areas of the sale area, the water table of the confined aquifer closely follows local topographic features. Groundwater can be obtained at depths of less than 50 feet and many shallow household wells have been developed for domestic use throughout the Anchorage area, however, "[m]ost water wells in the Anchorage area are between 100 and 300 feet deep." (Barnwell, et al., 1972:40). The alluvial fans of North and South Forks Campbell Creeks are potential areas for the development of shallow-well public water supplies (Barnwell, et al., 1972).

In the Conners Lake and Bog area, near the center of Anchorage, peat is present in the surface throughout all undisturbed areas. The peat averages 4 to 12 feet thick. Beneath the peat layer, lies a sand and gravelly silt layer about 11 to 57 feet thick. These layers make up the primary unconfined aquifer. Beneath that lies a poorly permeable layer of silty clay and clayey silt known as Bootlegger's Cove Clay. This clay layer caps the artesian aquifer below. Poorly sorted glacial deposits several hundred feet thick hold and transmit water beneath Bootlegger's Cove clay. Water flowing through or beneath the Connors Bog flows northwest to Knik Arm (Glass, 1986a).

Matanuska-Susitna Groundwater

The bedrock surface area of the Matanuska Valley is covered by Quaternary-age unconsolidated deposits ranging in thickness from less than 10 feet near the Bodenburg Butte area to an unknown thickness greater than 650 feet in the Scott Road area of Palmer (LaSage, 1992). During the most recent periods of glacial advance, glacial drift including till, was deposited over bedrock. When the ice receded, ice-contact deposits produced the uneven terrain west of the Glenn Highway (LaSage, 1992; citing to Reger and Updike, 1983). Tidal silts and clays of the flood plains and estuarine flats at the head of Knik Arm are greater than 200 feet thick (LaSage, 1992; citing to Trainer, 1960).

Palmer area ground water is derived primarily from saturated sand and gravel deposits within 150 feet of the surface. Both confined and unconfined aquifers occur throughout the area (LaSage, 1992)(Jokela, et al., 1990). Freethy and Scully (1980) noted that the highest yields in excess of 4,000 gallons per minute (gpm) have been obtained from wells in unconfined aquifers in alluvium adjacent to present-day rivers (La Sage, 1992). While ground water gradients are usually towards the streams, there are anomalies. East and southeast of Palmer the gradient reverses allowing the Matanuska River to recharge ground water. Also, ground water flow direction is known to reverse temporarily during and after the flooding that occurs from Lake George glacial dam break (LaSage, 1992; citing to Trainer, 1960).

Most of the wells in the Palmer area are private domestic wells completed to a depth of less than 150 feet. Three wells provide the City of Palmer with a public water supply and those were drilled to a depth greater than 600 feet. Estimated yields range from 0.5 gpm in single-family domestic wells to 1,200 gpm from a city well. Homeowners most often report a yield of 10 gpm, and LaSage (1992) reports that 90 percent of the well logs containing information about yield flowed at 30 gpm or less (LaSage, 1992:6). Maynard (1987) corroborates this yield.

Groundwater withdrawals are highest during the summer agricultural growing season. Even so, ground water usage in the Palmer area may be less than what is potentially available. Still and Brunett (1987) noted that despite several decades of industrial pumping (irrigation), water-levels in nearby wells did not change significantly over time (LaSage, 1992).

Jokela, et al. (1990) developed a regional water table map for the Palmer – Big Lake area. The map shows watershed boundaries, water-table contours, regional and local groundwater flow directions, and individual well locations. The map can be used to infer regional and local flow directions of groundwater (Jokela, et al., 1990). In the early 1980s, three out of every four wells drilled in the Big Lake area were drilled to a depth of less than 65 feet (Jokela, 1990; citing to Dearborn and Allely, 1983).

In the Houston area, glacial drift and alluvial deposits between 0 and over 180 feet thick overlie the bedrock. Glacial drift is composed of till and an undifferentiated mixture of materials ranging in size from clay-sized particles to boulders, and glaciofluvial deposits. The latter may be well-sorted gravel or gravelly sand deposits. Permeable deposits of sand and gravel are present along the Little Susitna and Little Meadow Creek (Maynard, 1987).

Groundwater in the Houston area is readily obtained from the gravel and sand layers of the near-surface glacial and alluvial deposits. The sandstone and coal layers of the sedimentary bedrock sequence also supply the area with groundwater (Maynard, 1987). In a 1987 paper, Maynard (1987) reports that wells in the Houston area range in depth between 12 feet and 300 feet in depth. Half of the 220 wells surveyed were 30 to 90 feet deep.

Despite being close to each other, well depths vary considerable throughout the region. “The percentage of wells drilled deeper than 100 feet is higher north of Loon Lake.” (Maynard, 1987:2) Estimated well yields range from 2 to 3 gpm in domestic bedrock wells to 150 to 250 gpm from wells at the Houston Junior-Senior High School and the ADFG Fish Hatchery at Big lake (Maynard, 1987). Private supply wells yield between 10 and 50 gpm, but in areas immediately adjacent to the Little Susitna River, yields may range between 50 and 1,000 gpm (Maynard, 1987; citing to Feulner, 1971).

Kenai Peninsula Groundwater

As with all of Cook Inlet, most wells tap upper unconfined aquifers throughout the peninsula. More than 60 percent of the housing units in Anchor Point, Clam Gulch, Cohoe, Kalifonsky, Kasilof, Nikiski, Ninilchik, Ridgeway and Sterling have well water systems (ADCRA, 1998). In the Cook Inlet basin, freshwater aquifers become saline below 3,000 ft level (Kornbrath, 1996).

“The median depths to water in domestic wells are 35 ft. in the upper peninsula and 30 ft in the lower peninsula” (Glass, 1995:23). The median depth of domestic wells in the upper peninsula is 65 ft, and 71 ft. in the lower peninsula (Glass, 1995:22). Near the city of Kenai, median depth of domestic wells is 66 feet and median depth to water is 33 feet (Bailey and Hogan 1995:8). Public, commercial, or industrial wells are drilled to depths necessary for higher yield. The maximum reported yield is 4,000 gpm from a 317-foot deep industrial well in the North Kenai area (Glass, 1995:22) The maximum thickness of unconsolidated sediments is about 750 feet. Yields from these sediments, such as sand and gravel aquifers near Nikiski, are generally higher (>1000 gpm.) than from bedrock wells (<8 gpm.)(Glass 1995:42).

At one site, in the Nikiski area, layers of silt and clay between unconsolidated sediments create three distinct aquifers. “The top of the upper confining bed is about 30 meters below the land surface and the top of the lower confining bed is about 60 meters below the land surface” (Bailey and Hogan 1995:8).

In the Nikiski area, the upper aquifer is unconfined and hydraulically connected to area lakes and streams as well as to a middle aquifer. This upper aquifer, which is the source of private wells, can be seen discharging along inlet bluffs at the high tide line. The base of the upper aquifer consists of clay and silt and usually conforms to surface topography. The lower two aquifers are confined and separated by a silt and clay layer more than 100 feet thick and the hydraulic connection between the lowest aquifer and the upper two is weak. Data on the lower confined aquifer suggest that it is discontinuous (Bailey and Hogan, 1995).

In the Sterling area, most wells tap water-bearing sand and gravel deposits in the glacial drift, referred to as the Quaternary aquifer. “The composition of the Quaternary aquifer varies considerably over short distances in the Sterling area. Water wells tapping the Quaternary aquifer range from 5 to 113 ft deep.”(Munter and Maurer, 1991:3)

The use of water table maps derived from surface deposit information indicate that groundwater generally flows toward the Moose and Kenai rivers with variability associated with local aquifer heterogeneity and landform and surface water features (Munter and Maurer, 1991).

Regarding the deltaic deposits of the Crooked Creek area in the Kasilof River floodplain, “a water table aquifer 30 ft to 80 ft thick commonly characterizes these sediments in the area north of the Kasilof River.” (Nelson and Johnson, 1981:13). A well near a bog in this area at an elevation of about 200 ft., had blue clay down to the 100 ft level where there was water-bearing gravel (Nelson and Johnson, 1981:13).

Average depth of wells in the lower peninsula ranges from 37 to 142 feet (Ireland, 1995). Most public wells in this area are clustered around population centers along the Sterling highway. Nelson and Johnson (1981) conducted local aquifer reconnaissance along the Sterling highway from the Kasilof River to Anchor Point. Referring to oil well data, freshwater aquifers are believed to be only 300 ft to 600 ft thick in the area between Ninilchik and Homer (Nelson and Johnson, 1981:4).

In the Homer area, bedrock consists of consolidated sand, silt, and clay interbedded with layers of coal and ash (Hall, 1995:13). Wells drilled in an unconfined aquifer near the surface yield from 6 to 25 gpm. Wells drilled into a bedrock aquifer north of the bluff have larger yields than those drilled in the unconfined layer (Hall, 1995). Most individual water wells tap shallower aquifers in the Homer area. Waller, et al; (1968) have reported that natural gas seepage into newly constructed wells in the Homer area was of sufficient quantity to ignite after having been stored in taps overnight. Some groundwater supplies near the surface at Homer are hard and high in sulfur content (Waller et al., 1968).

Waller and others (1968) described and delineated at least six aquifers in the Homer area, although boundaries were inferred. Groundwater is derived from wells completed in either Quaternary or Tertiary-age bedrock and deposits. Tertiary aquifers of the Kenai Group in the Homer area generally cover areas greater than 500 ft in elevation, with the exception of the Fritz Creek watershed where the Tertiary aquifers occur above the 1000 ft level (Waller, 1968). Aquifers closer to sea level may yield brackish water in the Homer and Kachemak area.

The Quaternary material of the Fritz Creek watershed are predominantly glacial moraine deposits consisting of glacial till and outwash stream deposits. Ten to twenty gallons per minute may be attained from sand and gravel beds in this aquifer (Waller, 1968). However, “[t]ill has low permeability, and most wells in the morainal areas penetrate the underlying bedrock.” (Nelson and Johnson, 1981:10). For more information about the possible impacts of oil and gas activities on freshwater resources, see Chapter Five.

c. Drinking Water Sources and Groundwater

Drinking water in the area is obtained from public drinking water systems, private wells and surface springs. Some communities derive water from wells, while others have surface collection systems. Surface drinking water is collected or siphoned from springs or seeps where an aquifer meets the surface, or from headwaters, streams, rivers or lakes further downstream. (ADCRA, 1998).

The USGS, ADEC, Kenai Peninsula Borough, and ADNR, Division of Mining and Water Management, collect and disseminate data on water quality in Alaska. The USGS Ground Water Site Inventory (GWSI) database contains information from more than 4,680 domestic, public, commercial, and industrial wells in the Kenai peninsula, including data from 690 wells in the lower peninsula (Glass, 1995:18). The Division of Mining and Water Management Well Log Tracking System (WELTS) contains some information about domestic water wells in the area, including well depth.

In the Matanuska-Susitna valley, communities with public water systems include Palmer and Wasilla. In Houston, 60 percent of residents have individual wells. The local school uses its own well water system. The remainder of Houston's residents haul water. More than half of homes in the Willow area use individual wells, and the remainder haul water. The local school operates its own water system. Sixty-two percent of homes in the Wasilla area have individual water wells, and the City operates a piped water and sewer system to supply water to the remainder. Water is provided by many wells with a storage capacity of 2.3 million gallons. Northwest of Wasilla, in Meadow Lakes, eighty percent of homes have individual well water systems. Nearly all Palmer homes derive water from the City's public well water system. The schools and Palmer Correctional Center operate individual well systems. About 85 percent of Big Lake area homes have individual water wells. The schools and Big Lake shopping mall also have individual well systems. Most residents of Alexander Creek, located 27 miles northwest from Anchorage, use creek water, but many also have well water systems in this small community. Seventy percent of Knik residents have individual water well systems and the remainder haul water (ADCRA, 1998)

The communities of Anchorage, Peters Creek, Chugiak, Eagle River, and Girdwood are all served by the MOA's Water and Wastewater Utility (AWWU) system. This public water system consists of two surface collection units (Ship Creek and Eklutna Lake) and a well unit (AWWU, 1997). The Ship Creek water facility obtains its water from a diversion dam on upper Ship Creek in the Chugach Mountain Range. Both upper Ship Creek and Eklutna lake waters are naturally protected from human pollution because the Chugach National Forest surrounds their headwaters. Water from Eklutna lake is delivered to Peters Creek, Chugiak, Eagle River and Anchorage by pipeline. Residents of Bird and Indian derive their water from private wells (AWWU, 1997). AWWU also maintains 22 deep wells (>200 feet) located throughout the MOA, and generally serve as a stand-by source for use during emergencies and high demand periods. The AWWU system served 206,650 persons in 1997. The service area covers over 125 sq. mi. and has 680 miles of main. (AWWU, 1997) (AWWU, 1998).

Public water systems are often installed with wastewater systems. Some communities have wastewater systems, while most rely on individual septic systems for sewage disposal. Larger communities have community sewer systems. AWWU's water treatment process surpasses the most stringent EPA filtration standards. Each treatment plant uses a modern, multiple-barrier treatment process that includes coagulation, flocculation, sedimentation, filtration, and disinfection. The treatment process produces water high in quality when each process is optimized (AWWU, 1997).

On the Kenai Peninsula, most potable water supplies used by the public rely on groundwater sources. Individual wells provide water for outlying residences, government facilities and industrial facilities. Communities with public water supply systems include Tyonek, Kenai, Soldotna, Nikolaevsk, Homer, Seldovia, Port Graham and Nanwalek. In 1990, the communities of Anchor Point, Kenai, Nikiski, Ninilchik, Soldotna, and Port Graham had community wells. The city of Soldotna obtains water from five wells located within the city which range in depth from 95 to 125 feet (KPB 1990:1-7). In 1990, communities with surface water sources were Halibut Cove, Jakolof Bay, Nanwalek, Port Graham, Seldovia, Kachemak, Homer, Nikolaevsk, and Tyonek. Typically, residents without a community drinking water system or a private well will either haul water from another source or obtain their water from a spring or seep located near their residence (ADCRA, 1998). Baseline water quality measurements for many drinking water sources on the Kenai Peninsula can be found in Glass (1995), and Hall (1995).

The Bridge Creek Reservoir, which is the principal source of drinking water for the city of Homer, has a 3.2 sq. mi. drainage area and is located north of the city at the headwaters of Bridge Creek, between 880 and 940 feet above sea level. The 65-foot high Bridge Creek Dam was built in 1975 upon layers of coal, sandstone, siltstone, and unconsolidated deposits. A subsurface profile along the dam axis generated from well bore tests indicates that these layers dip toward the north (Shannon and Wilson, 1990). Guidelines require a 200 foot setback restriction on wastewater disposal systems near the reservoir (Bevan, 1995). The southern extent of the sale area boundary is roughly three miles from the Bridge Creek Reservoir watershed as delineated in Shannon & Wilson (1990).

Coastal aquifers may be hydraulically connected to the ocean or other saline waterbodies. Under natural conditions, groundwater flow is generally toward the coast. In island settings and beneath offshore bars and spits, fresh groundwater occurs as an unconfined lens-shaped cell floating on saline groundwater (USGS, 1986).

Specific issues relating to water quality of the sale area are discussed in Chapter Five. Cumulative effects of oil and gas activities on water quality are discussed in Chapter Five.

4. Geology

a. Surficial geology

Sporadic periods of glacial advance and retreat have resulted in complex geologic strata and horizons in the Kenai lowland, the west side of Cook Inlet, Susitna Valley, and west Anchorage. Karlstrom (1964) described five periods of glaciation in the Cook Inlet basin, the last two of which were associated with proglacial lakes below the 500 ft level. The Fox River valley and Kachemak Bay were ice-filled, and Tustemena Glacier extended throughout the Kasilof River basin to the coast. Glaciers at the present-day headwaters of Deep Creek and Anchor River deposited materials in stream channels that approximately parallel present stream channels (Nelson and Johnson, 1981:8).

Glaciers are responsible for many distinctive land features such as alpine troughs, scraped and scoured valley floors, and broad outwash plains. Drainage patterns and glaciers often follow faults, carving out valleys and exposing ancient layered plains. The complex mixture of gravel, sand, silt, and clay deposited by glaciers is called till. The most common glacial deposits found in the region are moraines which are composed of glacial till laid down in fairly regular, low, linear hills at the edges of glaciers (AEIDC, 1974:44).

The Coastal lowlands from Point Possession to the head of Kachemak Bay, including Kenai, Soldotna, and Homer, generally include low rolling glacial moraines and depressions filled by lakes and muskeg. Many rivers and streams flow through this area. Soils range from gravely clay loam to gravely sand mantled with silty material and bands of volcanic ash (KPB, 1990:1-14).

On the west side of Cook Inlet the coastal lowlands between Tuxedni Bay and Granite Point consist of nearly level, poorly drained outwash plains deposited by large glaciers in the Aleutian Range and Chigmit

Mountains. The outwash plains are braided with meandering and shifting stream channels. Most soils consist of sandy glacial outwash, silt, tidal sediments and gravelly riverwash. The water table is high in most of this area with the exception of a few well-drained natural levees and ridges. North of Granite Point, soils and topography are similar to the coastal lowlands on the east side of Cook Inlet, with glacial moraines and depressions, pothole lakes and soils formed from gravely clay, sand and silt (KPB, 1990:1-15).

b. Bedrock Geology

The Cook Inlet basin is a geologically active zone of convergence for two tectonic plates, the Pacific and the North American. Continental land masses typically are either inactive regions of old rocks, such as in central Canada, or active belts of mountain-making material, characteristic of most of Alaska (Strahler & Strahler, 1984).

The origins and evolution of all continental materials are important to understanding geology. Igneous rocks cool at or near the earth's surface and form the material for two other rock types. Metamorphic rocks are formed and reformed in the cataclysms of mountain building, physically, chemically and molecularly altered by intense heat and pressure. Sedimentary rocks, like shale and sandstone, are derived from the decomposition and disintegration of older rocks. The resultant material is deposited as sediment, which is then compacted through burial. Petroleum and natural gas are almost always found in sedimentary rocks.

Continental and ocean basin materials make up the earth's crust, which rides or floats as tectonic plates on the planet's semi-molten mantle. Where these plates meet, they either move in opposite directions as with mid-ocean rifting, slide past each other as in California, or collide as in Southcentral Alaska. When plates collide, some of the less dense silica-rich continental materials are manipulated, faulted and folded into mountains, while more dense oceanic basalt and remaining silicon-rich rocks are subducted and driven back toward the earth's hot mantle. Melted subducted rocks then rise and generate volcanic plumes near plate boundaries.

The Pacific plate slips along California and the Pacific Northwest until it subducts beneath the continental materials making up Alaska, the Bering Sea and Asia. The northern subducting edge of the Pacific plate extends from just east of Asia through Prince William Sound and up into central Alaska creating a subduction zone deep beneath the surface (AEIDC, 1974) and a deep ocean trench called the Aleutian trench. This combination of subduction and fault slipping has produced a chain of coastal mountain ranges including the Chugach and Kenai mountains and an arc of volcanoes, known as the Aleutian archipelago. This fissure system in the earth's crust encompasses the Pacific Ocean, is marked by continuous instability, and is often referred to as the Ring of Fire (AEIDC, 1974)(Strahler & Strahler, 1984 and Ryherd, 1997).

The processes of uplift and subsidence, coupled with erosion, deposition and sea level changes have formed the underlying geology and topographic features of today's Cook Inlet. The nature and distribution of geologic materials have a direct bearing on location and abundance of mineral and water resources, slope gradients and stability, and the distribution of vegetation (AEIDC, 1974:38).

During the late Paleozoic and early Mesozoic time (see Table 2.1), sediments were deposited in a sea that occupied the Southcentral Region of Alaska. A volcanic island arc occupied a widespread area in the general vicinity of the now existing Alaska Range, erupting lava and volcanic materials into adjacent areas. The area occupied by the island arc was deformed and uplifted during Triassic time, providing a source of sediments which were deposited to the south in the adjacent marine basin (AEIDC, 1974:41 and Ryherd, 1997).

Uplift and erosion of these granitic bodies during Jurassic and Cretaceous times provided the material for a thick sequence of continental shelf sediments deposited in an adjacent, low lying basin which extended from the southern Alaskan Peninsula through the Cook Inlet region to the Copper River Basin. Here fine-grained sediments rich in organic material were deposited along with sands and clays, providing the possible source beds and reservoir rocks for the Tertiary petroleum reservoirs of Cook Inlet (AEIDC, 1974:41 and Ryherd, 1997).

Table 2.1 Geologic Time

Eras	Periods	Epochs	Began Approximate Number of Years Ago
Cenozoic	Quaternary	Holocene (Recent) Pleistocene (Glacial)	10,000 1 million
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	7 million 25 million 40 million 60 million 68-70 million
Mesozoic	Cretaceous Jurassic Triassic	Late and Early	135 million 180 million 225 million
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian		270 million 325 million 350 million 400 million 440 million 500 million 600 million

Adapted from Webster's Ninth New Collegiate Dictionary, 1991:512 and AEIDC, 1975:37

During the Tertiary Period in the Cook Inlet basin, deposition of sand and gravel alternated with luxuriant swamp vegetation growth. Through this repetitive cycle of vegetative growth and sediment deposition, peat layers were developed and buried, producing present-day coal formations. The sands and gravels would later become oil and gas reservoirs (AEIDC, 1974:41).

The Susitna basin is interpreted as a northern extension of the Cook Inlet basin, but separated by the Castle Mountain fault, a major regional structural feature of Southcentral Alaska. The structural style of the Susitna basin is a combination of graben and half-graben basement faulting. The Tertiary sedimentary fill consists of largely the same formations as are found in Cook Inlet. However, Eocene-age West Foreland Formation and Oligocene age Hemlock Conglomerate reservoir rocks appear to be missing in the Susitna basin. It is significant that the Jurassic oil-prone source rock found in the Cook Inlet basin have not been found in wells or outcrops. (Ryherd, 1997)

Nine oil and gas exploration wells and four core holes have been drilled in the Susitna basin. All exploration wells were plugged and abandoned as dry holes, though some did have minor gas shows. The two wells drilled near the deepest part of the basin were the Union Texas Pure Kahiltna Unit #1, completed in March 1964 to a total depth of 7,265 feet, and the Unocal Trail Ridge Unit #1, completed in October 1980 to 13,708 feet. Both wells probably bottomed in volcanic rocks of the Talkeetna Formation.. Coal beds become prominent in the lower part of both of these wells, suggesting a correlation with the coal-bearing formations in the Cook Inlet basin that produce natural gas. (Ryherd, 1997)

Turner and Wescott (1982) report that the granitic rocks beneath Houston are continuous with the Tertiary-to-Cretaceous-age granitic batholith of the Talkeetna Mountains. Up to 2,000 feet of coal-bearing Tertiary-age sedimentary rocks overly the granitic bedrock in the Farms Red Shirt Lake #1 and Inlet oil Fish

Creek #1 wells. The sedimentary section north of Castle Mountain Fault is about 2,000 feet thick, while south of the fault it is estimated to be at least 20,000 feet thick (Maynard, 1987 and Ryherd, 1997).

Uplift in the Late Cretaceous through early Tertiary time period produced the Kenai and Chugach mountain ranges. These mountains were subsequently eroded, depositing sediments and coal-bearing formations above sea level in the coastal lowlands and foothill belt. During Eocene time, seas encroached onto the land and became the location of sediment deposition from the neighboring mountains (AEIDC, 1974:41).

Renewed uplift, deformation and faulting began in the late Tertiary period and continue today. As a result of the March 1964 earthquake, most of the western Gulf of Alaska including Prince William Sound was uplifted while the entire Cook Inlet basin from the Talkeetna mountains to Kodiak Island subsided. Areas of active volcanism still exist and are considered to have high geothermal potential. (AEIDC, 1974:41).

The Cook Inlet lowlands, which are less than 500 feet above sea level, are underlain by a thick sequence of coal-bearing rocks of Tertiary age, commonly referred to as the Kenai Group, which rest on Mesozoic rocks up to 30,000 feet thick. The Kenai Group rock sequences contains most of the existing oil and gas reservoirs found in the Cook Inlet basin. Thick unconsolidated, Quaternary-age deposits cover the bedrock (AEIDC, 1974:42).

Cretaceous and Jurassic-age rocks underlie the entire Cook Inlet basin. These rocks are highly metamorphosed and well cemented, and hence permeability and inter-granular porosity is poor. The Tertiary rocks of the Kenai Group are found at the surface along beach cliffs from Clam Gulch to the head of Kachemak Bay, and occur within about 150 ft of the surface throughout most of the Kenai Peninsula. The thickness of these rocks range from 0 ft at the Kenai Mountains to about 20,000 ft near Nikiski (Glass, 1995:16-17).

D. Petroleum Potential

The area considered in this finding has low to moderate petroleum potential. This represents ADNR's general assessment of the oil and gas potential of the area and is based on a resource evaluation made by the state[2]. This resource evaluation involves several factors including geology, seismic data, exploration history of the area, and proximity to known hydrocarbon accumulations.

[2] By contrast, MMS's uses a complicated computer technique called "Monte Carlo" to estimate undiscovered resources. This program assesses resources for geologic plays, without economic constraints being applied (without considering whether or not any of the resources present in the geologic plays can be economically produced). This type of assessment is an attempt by a team of geologists, geophysicists, engineers, computer modeling specialists, and others to develop sets of scientifically based hypotheses concerning the quantities of undiscovered oil and gas that could exist, in addition to the known or proved reserves. The methodology generally relies on computer probabilistic modeling of geologic plays. Once this estimate has been done, MMS then utilizes an economic program to estimate the portion of the resources within the plays that would be economically recoverable at various prices. These types of assessments are quite speculative and result in ranges of estimates of the quantities of oil and gas at various probability levels. Time has shown that these estimates are rarely on target and are more useful as a management decision tool to rank the different areas for planning purposes.

Instead of relying on a computer model, DO&G petroleum geologists map potentially prospective subsurface rock units by using confidential seismic and well data, public well data, production and historical performance information from existing fields, and other published reports. However, the only way to verify the presence of oil and gas is to drill, and even after a discovery is made the estimate of the reserves is speculative. Still, each company's assessments may be quite different from each others and the division's because of the complicated nature of petroleum generation, migration, and trapping. Therefore, DO&G geologists and economists believe that the best approach is to provide a relative ranking in general terms.

Cook Inlet is a mature, producing petroleum basin which has seen extensive exploration and development over the past 30 years. The chances of finding undiscovered petroleum reservoirs is reduced by the fact that extensive exploration has already taken place and there is a corresponding lack of major new discoveries. The Susitna basin has not been extensively explored and as pointed out in the geology discussion, is a much shallower basin than Cook Inlet.

In order for an accumulation of hydrocarbons to be recoverable, the underlying geology must be favorable. This may depend on the presence of source and reservoir rock; the depth and time of burial; and the presence of migration routes and geologic traps or reservoirs. Source rocks are organic-rich sediments, generally marine shales, which have been buried for a sufficient time, and with sufficient temperature and pressure to form hydrocarbons. As hydrocarbons are formed, they will naturally progress toward the surface if a migration route exists. An example of a migration route might be a permeable layer of rock in contact with the source layer, or fault fractures that penetrate organic-rich sediments. A hydrocarbon reservoir is permeable rock that has been geologically sealed at the correct time to form a “trap.” The presence of migration routes therefore affects the depth and location where oil or gas may pool and form a reservoir. For a hydrocarbon reservoir to be producible, the reservoir rock must be of sufficient thickness and quality (good permeability and porosity), and must contain a sufficient volume or fill of hydrocarbons to be produced. Another factor used by the division to assess the petroleum potential of the area considered in this finding is the area’s history of petroleum exploration and development. A well-documented history of petroleum discoveries and production indicates that petroleum reservoirs do exist.

Some portions of this area have higher potential because of more favorable geology and proximity to existing fields, while other portions of the area may have lower potential because they are either more distant from production areas, the geology is less favorable, or the exploration history is less encouraging. Areas with lower potential may still contain hydrocarbon accumulations.

The presence of dry gas source rocks in the Susitna basin, similar to those found in the Cook Inlet basin, and the apparent absence of equivalent oil-prone source rocks indicate that the potential for finding gas in the Susitna basin is much greater than for finding oil (Ryherd, 1997)

In the Cook Inlet basin, sediment thickness increases from north to south and source rock potential improves, which is correlated with an increased chance of finding oil and gas. At the fringes of the sale area, thinning sedimentary rocks and metamorphic and igneous rocks have less potential for generating or containing oil and gas deposits (Ryherd, 1998).

The process of evaluating the oil and gas potential involves the use of data including seismic and well engineering information, which by law the division must keep confidential under AS 38.05.035(a)(9)(C). In order to protect these data, the division must generalize the assessment that is made public.

E. References

ADCRA
1998 DRCA Community Database. Department of Community and Regional Affairs, Division of Municipal and Regional Assistance, Research and Analysis Section, http://www.state.ak.us.

ADEC
1998 1998 Section 303(d) Water Quality Limited Waterbodies. Division of Air and Water Quality.

ADF&G
1985b Alaska Habitat Management Guide, Southcentral Region Volume II, Distribution, Abundance, and Human Use of Fish and Wildlife. Alaska Department of Fish and Game, Habitat Division, Juneau, 1985.

ADN (Anchorage Daily News)
1997 A matter of degrees: Alaska temperatures have risen, but who knows if that will continue. S. J. Komarnitsky, November 2, p. A-1.

AEIDC
1974 Alaska Regional Profiles, Southcentral Region. Arctic Environmental Information and Data Center, University of Alaska, 1974.

AWWU (Anchorage Water and Wastewater Utility
1998 AWWU Annual Water Quality Report. Anchorage Water and Wastewater Utility, MOA.
1997 AWWU Annual Water Quality Report. Anchorage Water and Wastewater Utility, MOA.

Bailey, B. J., and Hogan, E. V.
1995 Overview of Environmental and Hydrologic Conditions near Kenai, Alaska. USGS Open-File Report 95-410, Anchorage, Alaska, 1995.

Barnwell, et al.
1972 Water for Anchorage: An Atlas of the Water Resources of the Anchorage Area, Alaska. William W. Barnwell, Raymond S. George, Larry L. Dearborn, John Weeks, and Chester Zenone, Prepared by the USGS, Water Resources Division, Alaska District in cooperation with the Municipality of Anchorage and the Greater Anchorage Borough.

Berg, Ed
1997 Ecological Change on the Kenai Peninsula since 1850. Ed Berg, Kenai National Wildlife Refuge, in The Cook Inlet Symposium-Abstracts of Papers and Posters, Watersheds 97', October 29-31, Anchorage.

Bevan, H.
1995 Personal Communication with Homer Public Works director Hugh Bevan to Brian Havelock, DO&G, October 10, 1995.

Freethey, G., and Scully, D.
1980 Water Resources of the Cook Inlet Basin, Alaska. USGS, Hydrologic Investigations Atlas, HA-620, 1980.

Glass, R.

1995 Ground-water Conditions and Quality in the Western Part of Kenai Peninsula, Southcentral Alaska. USGS Water-resources Investigations DRAFT Report.

1986a Hydrologic Conditions in Conners Bog Area, Anchorage, Alaska. Roy L. Glass, USGS in cooperation with the Municipality of Anchorage, USGS Water-Resources Investigations Report 86-4044, Anchorage.

1986b Hydrologic Conditions in the Klatt Bog area, Anchorage, Alaska. Roy L. Glass, USGS in cooperation with the Municipality of Anchorage, USGS Water-Resources Investigations Report 85-4330, Anchorage.

Hall, J. D.

1995 Overview of Environmental and Hydrologic Conditions near Homer, Alaska. USGS Open-File Report 95-405. Anchorage, 1995.

Homer News.

1995 Study Looks at Drilling's Effect on Watersheds. August 31, 1995.

Ireland, R.

1995 Memo regarding Well Log Tracking System (WELTS). ADNR, Division of Mining and Water Management, November 1995.

Jokela, et al.

1990 Ground-water Resources of the Palmer-Big Lake area, Alaska: A Conceptual Model. J. Brett Jokela, James A. Munter, and James G. Evans, ADNR, Division of Geological and Geophysical Surveys, Report of Investigations 90-4.

Karlstrom, T.N.V.

1964 Quaternary Geology of the Kenai Lowland and Glacial History of the Cook Inlet Region, Alaska. USGS Professional Paper 443.

Kornbrath, Richard

1996 Personal Communication from Richard Kornbrath, DO&G, to Brian Havelock, DO&G, March 6, 1996.

KPB

1990 Kenai Peninsula Borough Coastal Management Program. Kenai Peninsula Borough, Resource Planning Dept., June 1990.

LaBelle, et al.

1983 Alaska Marine Ice Atlas. Joseph LaBelle, James L. Wise, Richard Voelker, Robert Schulze, Gary Whol, University of Alaska, AEIDC, 1983.

LaSage, D. M.

1992 Ground-water resources of the Palmer Area, Alaska. ADNR, Division of Geological and Geophysical Services, Division of Water, Report of Investigations 92-3.

Maynard, D. L.

1987 Water-well data from the Houston Area, Matanuska-Susitna Borough, Alaska. ADNR, Division of Geological and Geophysical Surveys, Report of Investigations 87-17.

MSB, Matanuska-Susitna Borough

1983 Matanuska-Susitna Borough Coastal Management Program, August 1993.

MMS, Minerals Management Service, U. S. Department of the Interior

1995 Cook Inlet Planning Area, Oil and Gas Lease Sale 149, Draft EIS, Vol. 1, January 1995.

Munter, J. and Maurer, M.

1991 Preliminary Description of Ground-water Conditions at Sterling, Alaska. ADNR, Division of Geological and Geophysical Surveys, Public Data File 91-31, 1991.

Nelson, G. and Johnson, P.

1981 Ground-water Reconnaissance of Part of the Lower Kenai Peninsula, Alaska. USGS Water-Resources Investigations, Open-file report 81-905, 1981.

Overpeck, J., et al.

1996 Arctic Environmental Change of the Last Four Centuries. J. Overpeck, K. Hughen, D. Hardy, R. Bradley, R. Chase, M. Douglas, B. Finney, K. Gajewski, G. Jacoby, A. Jennings, S. Lamoreaux, A. Lasca, G. MacDonald, J. Moore, M. Retelle, S. Smith, A. Wolfe, and G. Zielinski, In Science, Vol. 278, November 14.

Prentki, R.

1997 Sediment Quality in Depositional Areas of Shelikof Strait and Outermost Cook Inlet: Year 1 Study Design and Preliminary Results. Presented by Richard T. Prentki, MMS, Alaska OCS Region at the Watersheds '97: Cook Inlet Symposium, Anchorage, October 30.

1996 Personal Communication from Richard Prentki, MMS, to Tom Bucceri, DO&G, January 24, 1996.

Reger, R. D. and Updike, R. G.

1983 Upper Cook Inlet region and the Matanuska Valley. In Pewe, T. L., and Reger, R. D., (eds.) Guidebook to permafrost and Quaternary geology along the Richardson and Glenn Highways between Fairbanks and Anchorage, Alaska: Alaska Division of Geological and Geophysical Surveys Guidebook 1, p. 185-259.

Ryherd, Timothy

1998 Personal Communication from Timothy Ryherd, Resource Evaluation Section, DO&G, to Brian Havelock, Division of Oil and Gas, ADNR, August 13.

1997 Personal Communication from Timothy Ryherd, Resource Evaluation Section, DO&G, to Kristina M. O'Connor, Division of Oil and Gas, ADNR December 19, 1997.

Shannon and Wilson

1990 Subsurface Profile Along Dam Axis, Bridge Creek Dam, Homer, Alaska. Shannon and Wilson, Inc. Dam Safety Inspection, July 1990. Taken from 1974 Drawing No. 1 of 7 from Job No. 3017.16 by CH2M Hill, Anchorage, AK, 1990.

Still, P. J. and Brunett, J.O.

1987 Ground-water Levels in Alaska, Water Year 1984. USGS, Open-File Report 87-230.

Strahler, A., and Strahler, A.

1984 Elements of Physical Geography, 3rd. Edition. John Wiley & Sons, New York, 1984.

Trainer, F. W.
1960 Geology and Ground-Water Resources of the Matanuska Valley Agricultural Area, Alaska. USGS Water Supply Paper 1494.

Turner, D. L., and Wescott, E. M.
1982 A preliminary investigation of the geothermal energy resources of the Lower Susitna Basin. University of Alaska Geophysical Institute Report UAG R-287, Fairbanks.

USGS
1995 Ground Water Studies. United States Geological Survey, FS-058-95, 1995
1985 Alaska Groundwater Quality. National Water Summary 1986 – Groundwater Quality: Alaska. USGS Water Supply Paper 2325.

Van Dyke, Bill
1996 Personal communication from Bill Van Dyke, DO&G, to Tom Bucceri, DO&G, January 24.

Waller, R.M., et al.
1968 Water Resources and Surficial Geology of the Homer Area, Southcentral, Alaska. USGS, Hydrologic Investigations Atlas HA-187, Washington, DC., 1968.

Zenone, C., and Anderson, G. S.
1978 Summary Appraisals of the Nation's Groundwater Resources-Alaska. Geological Survey Professional Paper 813-P, U.S. Government Printing Office, Washington D. C., 1978.